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ARMORED MEDICAL RESEARCH LABORATORY  
Fort Knox, Kentucky

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Project No. 3-1, 3-5.  
724.41 GNOML

22 July 1943 B

CONTROL OF GUN FUMES IN M4 SERIES MEDIUM TANKS  
BY POSITIVE-PRESSURE VENTILATION

1. PROJECT: 3 - Toxic Gases in Armored Vehicles. Supplemental Report on Sub-Project: 3-1 - Determination of the Characteristics and Effects upon the Crew of Gun Fumes From Firing of the Weapons in Tanks of the M4 Series, and Sub-Project: 3-5 - Correlation of Basic Ventilation Data with Gun Fume Studies and Development of an Effective Design of Improvement for the Control of Gun Fumes in M4 Tanks.

a. Authority - Letter Commanding General, Headquarters Armored Force, file 600.112-61 dated September 24, 1942.

b. Purpose - To determine the degree of improvement in control of the gun fume hazard in the M4 series of medium tanks resulting from conversion of the crew compartment ventilation from the negative-pressure type to positive-pressure.

2. DISCUSSION:

a. The toxic gas hazard arising from the firing of the weapons in the M4 series of medium tanks is created for the most part by the fact that the system of ventilation in the crew compartment is of the negative pressure type. Owing to the reduced pressure within the tank, air flow is inward. As a consequence, when the breech of the gun opens after the firing of a round, the volume of gas contained in the barrel is drawn immediately into the crew compartment, thus contaminating the atmosphere with carbon monoxide and other toxic or irritating gases.

b. In contrast, with a system of positive-pressure ventilation and consequent outward flow of air, the gaseous contents of the barrel are forced to the outside, thus greatly reducing the contamination of the atmosphere within the tank by gun fumes. The quantity of gas brought into the tank under this condition is limited for the most part to that amount carried by the shell casing.

c. An opportunity was presented in connection with the experimental development of a gas-proof tank to determine the benefits of positive-pressure ventilation from the standpoint of control of gun fumes. The tests herein reported were conducted in accordance with the standard procedure, as outlined in Report on "Control of Gun Fumes in M4 Series Medium Tanks", Project Nos. 3-1 and 3-5; February 15, 1943.

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d. A description of the system of positive-pressure ventilation employed in the experimental tank is given in Second Partial Report on Project 3-9 "Determination of Ventilation Requirement for Gas-proofing Tanks of the M4 Series"; June 23, 1943.

e. A detailed discussion of the results of these tests is presented in the appendix.

### 3. CONCLUSIONS:

a. Conversion of the ventilation system in the M4 medium tank to one of the positive-pressure type provides an effective method of control of the gun fumes.

b. The development of a positive-pressure within the crew compartment of 1/2 inch water gage is sufficient to force the fumes from gun barrel to the outside.

### 4. RECOMMENDATIONS:

a. That the advantages of positive-pressure ventilation from the standpoint of control of gun fumes be considered with other advantages in making a final decision with reference to gas-proofing tanks.

b. That this report be distributed to agencies concerned with the development of the gas-proof tank.

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3 Incls.

#1 - Appendix  
#2 - Table 1 and 2  
#3 - Fig. 1

## APPENDIX

The benefits to be derived from positive-pressure ventilation in tanks, with respect to control of gun fumes were determined in connection with the experimental development and study of gas protection in an M4A3 tank. The tests consisted of standard gun fume trials conducted in accordance with procedures previously outlined. The weather, during the tests, was cool and rainy with variable winds, averaging approximately 8 mph. The wind direction, though variable, was generally head on or slightly quartering to the tank. Ammunition for the 75 mm gun consisted of H.E., M48, supercharge, while for the machine gun, calibre 30 M2 was employed.

Results of the tests are presented in tables 1 and 2 and in figure 1. For comparative purposes, the findings for a standard M4A3 tank, with engine idling, are also included.

The results of these tests are definite and by comparison with conditions in the standard tank, show that great improvement in atmospheric conditions within the tank results from the operation of the positive-pressure system of ventilation. With respect to the 75 mm gun, for example, the CO concentration in the turret was reduced to approximately 25% of the level which was found in the standard tank. This was true at a pressure of 1/2 inch, water gage, as well as at 1.0 inch pressure. Ammonia concentrations were also markedly reduced, the peak levels ranging during these tests from 40 to 94 ppm, with no eye irritation reported by the crew. In contrast to these findings, the peak ammonia concentration in the standard M4A3 tank ranged from 180 to the 400 ppm and smarting of the eyes with considerable watering was reported by all of the turret crew members.

The benefits of positive-pressure ventilation apply to the bow machine gun as well as the 75 mm gun, as shown in table 2. Concentrations of CO were markedly reduced as compared with the concentrations found in the standard tank.

In comparison with the maximum permissible average concentration of 0.05%, the concentrations of CO found in the experimental positive-pressure tank are entirely acceptable. Thus, it may be concluded that with a system of positive-pressure ventilation in the crew compartment, the gun fume hazard is largely eliminated and no additional control measures are required.

Incl # 1

Table 1

Carbon monoxide concentrations from 75 mm gun in experimental M4A3 tank with pressure ventilation as compared with standard M4A3 tank (engine idling).

Test Conditions	No. of Bursts	Loader, by MSA	Average Concentration - Percent Cent. Flask Samples				Average Peak Conc. Percent. Loader	Clearance Pat. **
			Loader	Commander	Gunner	Bow		
Standard M4A3* Eng. Idling at 500 rpm	6	0.070	0.099	—	0.122	.016	0.33	32 Sec.
Exp. M4A3 with positive pressure = 1.0 in., w.g.	6	0.025	0.032	0.024	0.029	0.007	0.062	85 Sec.
Exp. M4A3 with positive pressure = 0.5 in., w.g.	6	0.021	0.017	0.019	—	—	0.082	23 Sec.

\* Data from Report on Control of Gun Fumes in M4 Series Medium Tanks; Project Nos. 3-1, 3-5. February 15, 1943.

\*\* Time to clear 50 percent after 5 rounds fired.

Incl #2

Table 2

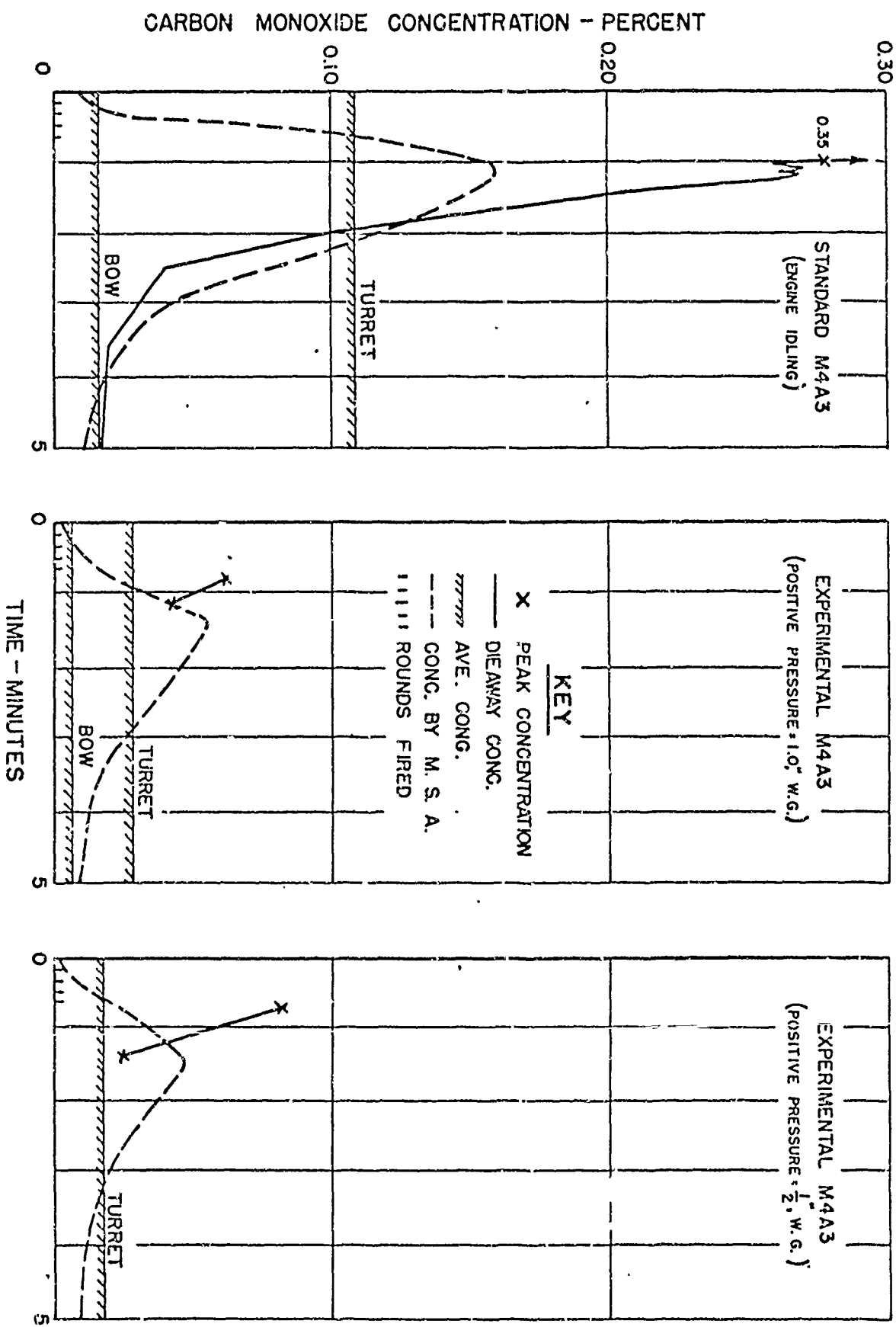
Carbon monoxide and ammonia concentrations from bow machine gun in experimental M4A3 tank with pressure ventilation as compared with standard M4A3 (eng. idling).

Test	No. Belts Fired	Aver. MSA*	Carbon Monoxide Concentration - Percent					Peak Ammonia Conc. ppm*
			Peak Conc.*	Aver. Conc. by Cont. Sampling				
				Turret		Bow		
				Loader	Gunner	Driver	Asst. Driver	
Standard M4A3 Eng. Idling at 500 rpm**	4		0.022	—	0.006	0.015	0.050	42
Exp. M4A3 with positive-pressure— 1.0 in., w. g.	2	0.005	0.014	0.000	—	0.003	0.003	42

\* Taken at Asst. driver's position.

\*\* See footnote, Table 1, for source of data.

Incl #2.



CARBON MONOXIDE CONCENTRATION FROM 75 MM GUN  
 (ONE BURST OF FIVE ROUNDS)  
 EXPERIMENTAL M4A3 TANK WITH POSITIVE PRESSURE VENTILATION  
 AS COMPARED WITH STANDARD M4A3 TANK

FIG. 1

Incl. # 3